U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

5.4.8 REACTOR WATER CLEANUP SYSTEM (BWR)

REVIEW RESPONSIBILITIES

Primary - Chemical Engineering Branch (CMEB)

Secondary - None

I. AREAS OF REVIEW

At the construction permit (CP) stage of review, the CMEB reviews the information in the applicant's safety analysis report (SAR) in the specific areas that follow. At the operating license (OL) stage of review, the CMEB review consists of confirming the design accepted at the CP stage and evaluating the adequacy of the applicant's technical specifications in these areas.

1. The design of components, design features which influence system availability and reliability, and interconnections with the reactor primary coolant and radwaste systems are reviewed. Removal of chemical impurities and fission products by the reactor water cleanup system (RWCS) is considered. The provisions for isolating the RWCS from the reactor system following liquid poison injection, holding filter and demineralizer beds in place if system flow is decreased, straining resins from return flows to the primary system, component venting, and resin transfer are reviewed.

2. The component design parameters for flow, temperature, pressure, heat removal capability, and impurity removal capability to assure the system capacity will meet the reactor coolant specifications are reviewed.

3. The quality group and seismic design criteria are reviewed.

4. The instrumentation and process controls provided to ensure proper system operation and system isolation when necessary, including instrumentation for (a) automatic system isolation to prevent removal of liquid poison in the event of standby liquid control system actuation and to prevent damage to the filter/

demineralizer resins, and (b) monitoring impurity removal (conductivity measurements), differential pressure across pressure-sensitive components, and temperature control prior to demineralization, are reviewed. In addition, the process controls responding to these measurements to maintain operation within the established system parameters are reviewed.

5. The review for fire protection is performed as part of the primary review for SRP Section 9.5.1.

In addition, the CMEB will coordinate other branches' evaluations that interface with the overall review of the RWCS as follows:

The Auxiliary Systems Branch (ASB) evaluates the effects of high and moderate energy piping failures outside the primary containment in the RWCS design, to ensure that the other safety-related systems and equipment will not be made inoperable, as part of its primary review responsibility for SRP Section 3.6.1. The ASB also evaluates the capability of safety-related systems to withstand the effects of internally-generated missiles, both inside and outside the primary containment, as part of its primary review responsibility for SRP Sections 3.5.1.1 and 3.5.1.2. The ASB also evaluates the capability of the safety-related systems to withstand the effects of missiles generated by natural phenomena and externally-generated missiles, as part of its primary review responsibility for SRP Sections 3.5.1.4 and 3.5.2, respectively. The ASB also evaluates the capability of structures housing the RWCS to withstand external and internal flood conditions, as part of its primary review responsibility for SRP Sections 3.4.1 and 9.3.3. The Materials Engineering Branch (MTEB) reviews the material properties, material compatibility, and the inservice inspection requirements of the portions of the RWCS that comprise the reactor coolant pressure boundary, as part of its primary review responsibility for SRP Sections 5.2.3 and 5.2.4. The MTEB also verifies that inservice nondestructive examination requirements are met for the RWCS Class 2 and 3 components, as part of its primary review responsibility for SRP Section 6.6. The Instrumentation and Control Systems Branch (ICSB) reviews the instrumentation and components of the RWCS with respect to their capabilities, reliability, and conformance to the acceptable criteria in SRP Sections 7.1 and 7.6 and branch technical positions in SRP Appendix 7-A, as part of its primary review responsibility for these sections. Upon request from the CMEB, the Power Systems Branch (PSB) will evaluate the adequacy of the design, installation, inspection, and testing of all electrical systems for the RWCS, as part of its primary review responsibility for SRP Section 8.3.1. The Effluent Treatment Systems Branch (ETSB) reviews the liquid, gaseous, and solid waste management of the RWCS in SRP Sections 11.2, 11.3, and 11.4, respectively, and the process and effluent radiological monitoring aspect of the RWCS in SRP Section 11.5, as part of its primary review responsibility for these SRP sections. The Radiological Assessment Branch (RAB) reviews the RWCS with respect to maintaining occupational radiation exposure to as low as reasonably achievable and to provide radiation protection design features as part of its primary review responsibility for SRP Sections 12.1 and 12.3, respectively. The Equipment Qualification Branch (EQB) reviews the seismic qualification of Category I instrumentation and electrical equipment, and the environmental qualification of mechanical and electrical equipment, as part of its primary review responsibility for SRP Sections 3.10 and 3.11. The Structural Engineering Branch (SEB) determines the acceptability of the design analysis, procedures, and criteria used to establish the ability of seismic Category I structures housing the RWCS and the supporting systems, to withstand the effects of natural phenomena, such as the safe shutdown earthquake, the probable maximum flood, and tornado missiles,

as part of its primary review responsibility for SRP Sections 3.3.1, 3.3.2, 3.4.2, 3.5.3, 3.7.1, 3.7.2, 3.7.3, 3.8.4, and 3.8.5. The Mechanical Engineering Branch (MEB) determines the acceptability of the seismic and quality group classifications for the RWCS components, as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2. The MEB also determines that the piping, components, and structures of the RWCS are assigned in accordance with the applicable codes and standards, as part of its primary review responsibility for SRP Sections 3.9.1, 3.9.2, and 3.9.3. The MEB also reviews the adequacy of the functional testing programs of the isolation valves in the RWCS, as part of its primary review responsibility for SRP Section 3.9.6. The Containment Systems Branch (CSB) reviews the design of the isolation provisions of those portions of the RWCS that penetrate the primary containment, as part of its primary review responsibility for SRP Section 6.2.4. The reviews of technical specifications, and quality assurance of the RWCS are coordinated and performed by the Licensing Guidance Branch (LGB) and Quality Assurance Branch (QAB), as part of their primary review responsibilities for SRP Sections 16.0 and 17.0, respectively.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

The CMEB acceptance criteria are based on meeting the relevant requirements of the following regulations:

A. General Design Criterion 1 as it relates to the design of the RWCS and components to standards commensurate with the importance of its safety function.

B. General Design Criterion 2 as it relates to the RWCS being able to withstand the effects of natural phenomena.

C. General Design Criterion 14 as it relates to assuring the reactor coolant pressure boundary integrity.

D. General Design Criterion 60 as it relates to the capability of the RWCS to control the release of radioactive effluents to the environment.

E. General Design Criterion 61 as it relates to designing the RWCS with appropriate confinement.

Specific criteria and the positions of Regulatory Guides 1.26, 1.29, and 1.56 are used to meet the relevant requirements of GDC 1, 2, 14, 60, and 61 as follows:

1. The system should be capable of maintaining acceptable reactor water purity in normal operation and during anticipated operational occurrences, e.g., reactor startup, refueling, and condensate demineralizer breakthrough to assure reactor coolant pressure boundary material integrity in accordance with the requirements of General Design Criterion 14. The following points should be included in the system design:

    a. The system should be designed to maintain reactor water purity within the guidelines of Regulatory Guide 1.56 (reference 3) and the Technical

Specifications for Water Chemistry of Reactor Coolant System for Boiling Water Reactors. The system should provide demineralization of reactor water through mixed bed resins (beads or powdered) at approximately 1% of the main steam flow rate.

b. The nonregenerative heat exchangers should be designed to reduce the cleanup flow temperature to the demineralizer operating temperature when the regenerative heat exchanger cooling capacity is reduced as a result of partially bypassing a portion of the return flow to the main condenser or radwaste system.

c. The RWCS should have the capability to permit processing of excess reactor water during startups, shutdowns, and hot standby conditions. Interconnections between the reactor water cleanup and liquid waste and condensate storage systems to share the processing burden are acceptable.

d. The RWCS should be designed to permit processing of reactor water during periods of single active component failures or equipment downtime.

2. The reactor water cleanup system should include the following:

a. Provisions for automatically isolating the RWCS from the reactor coolant system in the event the liquid poison system is actuated for reactor shutdown.

b. Provisions for automatically isolating the RWCS in the event the nonregenerative heat exchanger effluent temperature exceeds the prescribed resin operating temperature for the cleanup demineralizer resins.

c. Means for automatically maintaining flow through filter/demineralizer beds in the event of low process flow or loss of process flow through the system, to prevent bed loss. The recirculation loop and holding pump subsystem provided for precoating can serve this purpose if it is activated on loss of flow or low flow conditions.

d. Means of transferring resins. Sight glass provisions (bull's eyes) are acceptable for monitoring resin transfers. Systems should be designed to prevent "resin traps" in sluice lines. A statement indicating that consideration will be given in the design to avoid resin traps, e.g., a statement that resin transfer lines will be designed to avoid resins collecting in valves, low points, or stagnant areas, will be acceptable for transfer line designs.

e. Provisions for draining and venting RWCS components through a closed system, i.e., not to the immediate atmosphere, in accordance with the requirements of General Design Criteria 60 and 61. The SAR should state that vent lines run to a ventilation duct exhausting from the plant.

f. Provision, in return lines to the reactor system or condensate system, of resin strainers capable of removing resin particles contained in demineralizer effluents.

3. To meet the requirements of General Design Criteria 1 and 2, the regulatory position C.2.c in Regulatory Guide 1.26 (reference 1) and regulatory positions C.1, C.2, C.3, and C.4 in Regulatory Guide 1.29 (reference 2), are applicable so that the portion of the RWCS extending from the reactor vessel and recirculation loops to the outermost drywell isolation valves should be designed to seismic Category I and Quality Group A. The remainder of the system outside the primary containment should be designed to Quality Group C and need not be seismic Category I. The precoating unit for demineralizers need not be designed to Quality Group C and need not be seismic Category I.

4. The RWCS should include provisions for monitoring:

   a. System effluent conductivity. Instrumentation should be consistent with the regulatory positions on instrumentation in Regulatory Guide 1.56 (reference 3).

   b. Temperature upstream of the demineralizer, to assure the ion exchange resin temperature limits are not exceeded.

   c. Differential pressure, to assure the design limits on filter/demineralizer septums and resin strainers are not exceeded.

III. REVIEW PROCEDURES

The reviewer will select and emphasize material from this SRP section, as may be appropriate for a particular case.

1. CMEB reviews the system description and piping and instrumentation diagrams (P&IDs) to determine the processing sequence, interconnections with other systems, and similarity to systems previously evaluated, and establishes that the following are considered in the applicant's design:

   a. Provisions to automatically terminate flow to the RWCS following liquid poison injection into the reactor water.

   b. Provisions to automatically terminate flow to the cleanup demineralizers if the nonregenerative heat exchanger effluent temperature exceeds the resin operating temperature limits.

   c. Provisions for automatically maintaining flow through filter/demineralizer units in the event system flow decreases to a point where the bed may drop from the septum.

   d. Provisions for monitoring resin transfers to assure transfers are complete and design considerations are incorporated to eliminate resin traps.

   e. Provisions for venting cleanup system components during drain, fill, and air mixing operations.

   f. Provisions for removing resin particles from cleanup system product water to prevent resins from entering the reactor system.

2. CMEB reviews the system capacity and processing flexibility and considers the following:

a. The process equipment, resin types, and bed volumes compared to those for similar reactors and the RWCS capability compared to the guidelines of Regulatory Guide 1.56 (reference 3).

b. The design flows and temperatures through the system to assure the criteria for outlet temperature relative to resin temperature are met.

c. The RWCS capability to process surplus refueling water prior to storage in the refueling water storage tanks or the condensate storage tanks.

d. Redundant or parallel components which will permit cleanup, if required, during periods of equipment downtime or single active component failures.

3. CMEB coordinates with MEB in the review of the quality group and seismic design classification of the system, and compares the design to the guidelines of Regulatory Guides 1.26 (reference 1) and 1.29 (reference 2) to assure conformance with acceptance criterion II.3 above.

4. CMEB reviews the instrumentation and controls for the reactor water cleanup system to assure that monitors are provided for:

   a. Conductivity of demineralizer effluent.

   b. Temperature and conductivity of demineralizer influent.

   c. Differential pressure across the demineralizer and across the resin strainers.

   CMEB assures that system controls are responsive to the monitor indications to maintain the required temperature and flow and that conductivity meters cover the entire range up to mandatory shutdown as delineated in the plant technical specifications in the final safety analysis report (FSAR).

IV. EVALUATION FINDINGS

CMEB verifies that sufficient information has been provided and that the review is adequate to support conclusions of the following type, to be included in the staff's safety evaluation report:

The reactor water cleanup system (RWCS) will be used to aid in maintaining the reactor water purity and to reduce the reactor water inventory as required by plant operations. Our review has included piping and instrumentation diagrams and process diagrams along with descriptive information concerning the system design and operation.

The staff concludes that the proposed design of Reactor Water Cleanup System (RWCS) is acceptable and meets the relevant requirements of General Design Criteria 1, 2, 14, 60, and 61. This conclusion is based on the following:

1. The applicant has met the requirements of General Design Criterion 1 by designing, in accordance with the guidelines of Regulatory Guide 1.26, the portion of the RWCS extending from the reactor vessel and recirculation loops to the outermost primary containment isolation valves to Quality Group A and by

designing, in accordance with position C.2.c of Regulatory Guide 1.26, the remainder of the RWCS outside the primary containment (excluding the precoating unit) to Quality Group C.

2. The applicant has met the requirements of General Design Criterion 2 by designing in accordance with positions C.1, C.2, C.3 and C.4 of Regulatory Guide 1.29, the portion of the RWCS extending from the reactor vessel and recirculation loops to the outermost primary containment isolation valves to seismic Category I.

3. The applicant has met the requirements of General Design Criterion 14 by meeting the positions of Regulatory Guide 1.56 in maintaining reactor water purity and material compatibility to reduce corrosion probabilities, and thus reducing the probability of reactor coolant pressure boundary failure.

4. The applicant has met the requirements of General Design Criteria 60 and 61 by designing a system containing radioactivity with confinement, by venting and collecting drainage from the RWCS components through closed systems.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using the SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

1. Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants."

2. Regulatory Guide 1.29, "Seismic Design Classification."

3. Regulatory Guide 1.56, "Maintenance of Water Purity in Boiling Water Reactors."

4. 10 CFR Part 50, Appendix A, General Design Criterion 1, "Quality Standards and Records."

5. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

6. 10 CFR Part 50, Appendix A, General Design Criterion 14, "Reactor Coolant Pressure Boundary."

7. 10 CFR Part 50, Appendix A, General Design Criterion 60, "Control of Releases of Radioactive Materials to the Environment."

8. 10 CFR Part 50, Appendix A, General Design Criterion 61, "Fuel Storage and Handling and Radioactivity Control."